PRE-CONCENTRATION TECHNIQUES FOR RESIDUAL COAL FROM BOTTOM ASH. PART 1 - METHODOLOGY AND PROCEDURES

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ABSTRACT. *The carbon content in ash differs depending on the quality of the coal, the efficiency of the combustion plant, the combustion parameters and so on. The separation of unburned coal from ash can be done for various purposes - to reduce the unburned coal content before its use (eg for cement production), to collect uncharged coal to further study its characteristics or to prepare some absorbents, graphite materials, etc. The choice of the separation procedure is therefore given by the purpose of the separation, the properties required for unburned carbon, or by the subsequent intended use.*

The UCB research team analyzed twelve pre-concentration procedures for residual carbon from bottom ash. The procedures and the methodology used for comparison are pointed out.

KEY WORDS: *pre-concentration procedures, char, bottom ash.*

1. INTRODUCTION

The University "Constantin Brancusi" of Targu Jiu (UCB) is actively involved since 2011 in an research effort to detect efficient directions to recover the coal ash generated by thermal power plants, prevalent in the Oltenia industrial area, particularly for using them as alternative raw material in the building industry [1]. Therefore, UCB continue and widens the efforts to recover coal ash through its participation in the European Project CHARPHITE consortium under the scope of the "Third ERA-MIN Joint Call (2015) on Sustainable Supply of Raw Materials in Europe.

The main goal of the project is to use the carbonaceous solid residue (char) from Oltenia bottom ash as substitution material for natural graphite in cutting-edge energy technologies, such as catalysts for electrochemical reactions in cell batteries or hydrogen and oxygen production by water electrolysis [2].

The UCB's research team contribution in this project mainly aims the separation of the char from fresh and landfilled bottom ash, and further assessment and utilization of the "char-free" coal ash [3].

2. METHODOLOGY AND PROCEDURES

Generally, the carbon residues (char) fractions can be separated from other fractions using wet processes (gravimetric separation, froth flotation and hydrophobic agglomeration in the upper hydrocarbon medium) or dry techniques (sieving, incipient fluidization and tribo -electrostatic separation). Compared to wet separation procedures, dry separation techniques do not pose a risk of leaching of soluble or contamination specimens, which may be problematic if, for example, the chemical composition is studied.

Under the scope of CHARPHITE project, we initially collected 100 kg of fresh bottom ash from the coal fired boilers Govora Combined Heat and Power Plant [4].

Once collected, the ash samples were immediately closed in plastic boxes, to preserve their original properties until the laboratory testing to determine the moisture concentration, bulk density and granulometry. Moisture was determined by drying the sample in an electric oven (150 liters capacity) at a temperature of 110 ^{o}C ± 2 ^{o}C by holding the maximum temperature for 10 hours.

Bulk densities (freely settled and tapped) and granulometry were determined after samples drying. The bulk density was determined following gravimetric method of STAS 1913/3-76 by weighting a known volume of bottom ash sample and using a gradated cylinder and an analytical balance.

Based on the results pointed out, a mechanical sieving trial was conducted using a set of sieves with the following nominal sieve opening in mm: 4; 3,15; 2,5 and 2.

The partner research team from University Politehnica Bucharest (UPB) conducted a preliminary determination of the fix carbon content and it resulted that FCC is much higher than in the lower size fractions and also in relation to the average value –table 1.

Table 1. Characteristics of initial ash and slag samples

Sample	**Size** [mm]	**Share** [%]	**FCC** [%]
PG 1	> 4	2,60	0,52
PG 2	3.15 – 4	3,14	38,82
PG 3	2.5 - 3.15	4,06	36,85
PG 4	2 - 2.5	5,82	31,27
PG 5	< 2	84,40	14,42

We collected another 150 kg of samples from the coal ash and slag stockpile belonging to Govora CHPP and, taking into account the preliminary results, we separated three fractions –see table 2.

Table 2. Characteristics of ash and slag samples

Proba	**Size [mm]**	**Share [%]**	**FCC [%]**
PG 6 	> 4	7,02	0,47
PG 7 	2 – 4	**16,65**	**28,44**
PG 8 	< 2	76,33	11,95

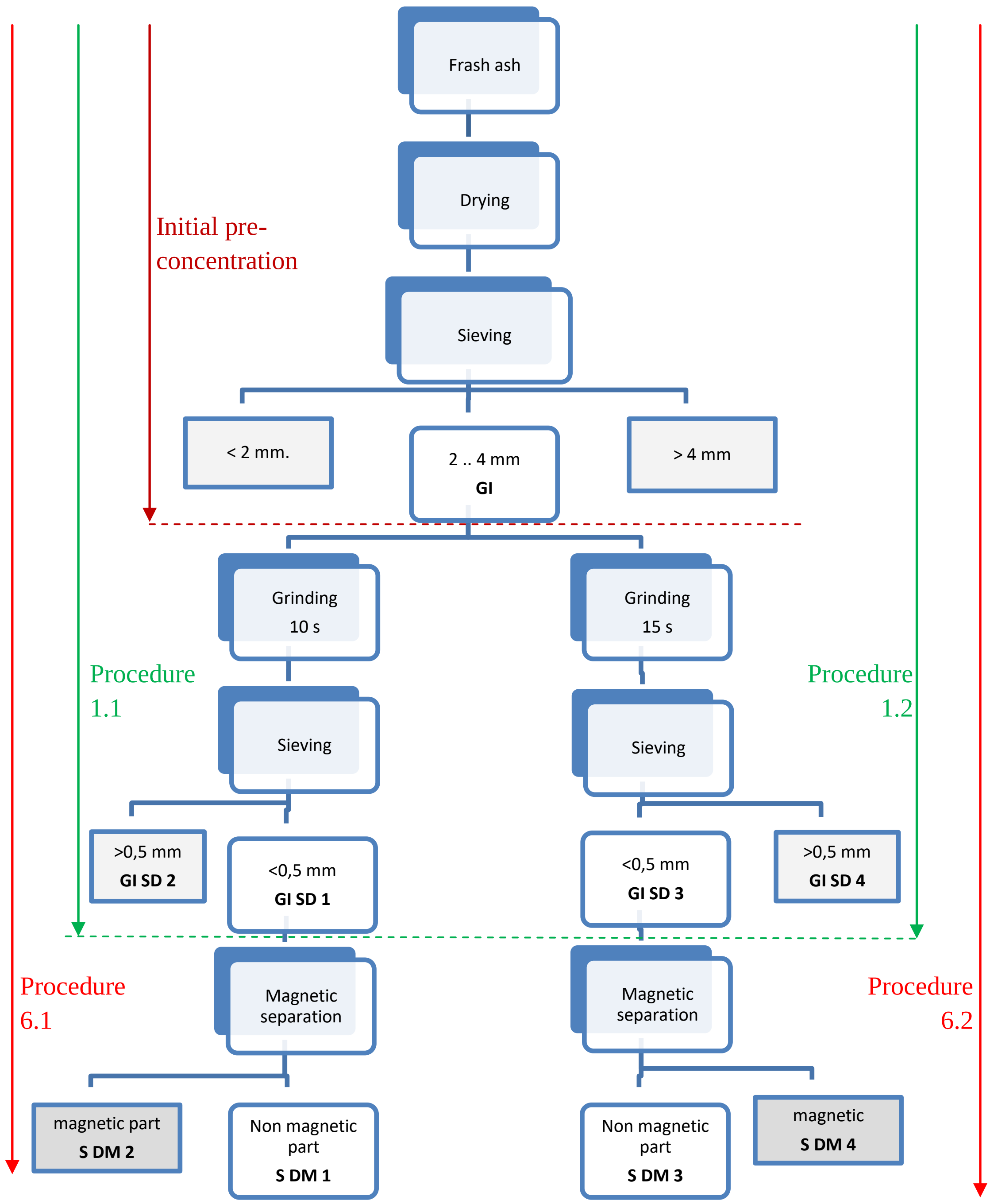
The fraction with highest FCC, respectively sample with the size between 2 and 4 mm, was named sample GI this point forward.

Starting from the sample GI, we developed 12 char enrichment procedures by repeatedly removing the inorganic matter through various processes such as sieving, flotation and magnetic separation.

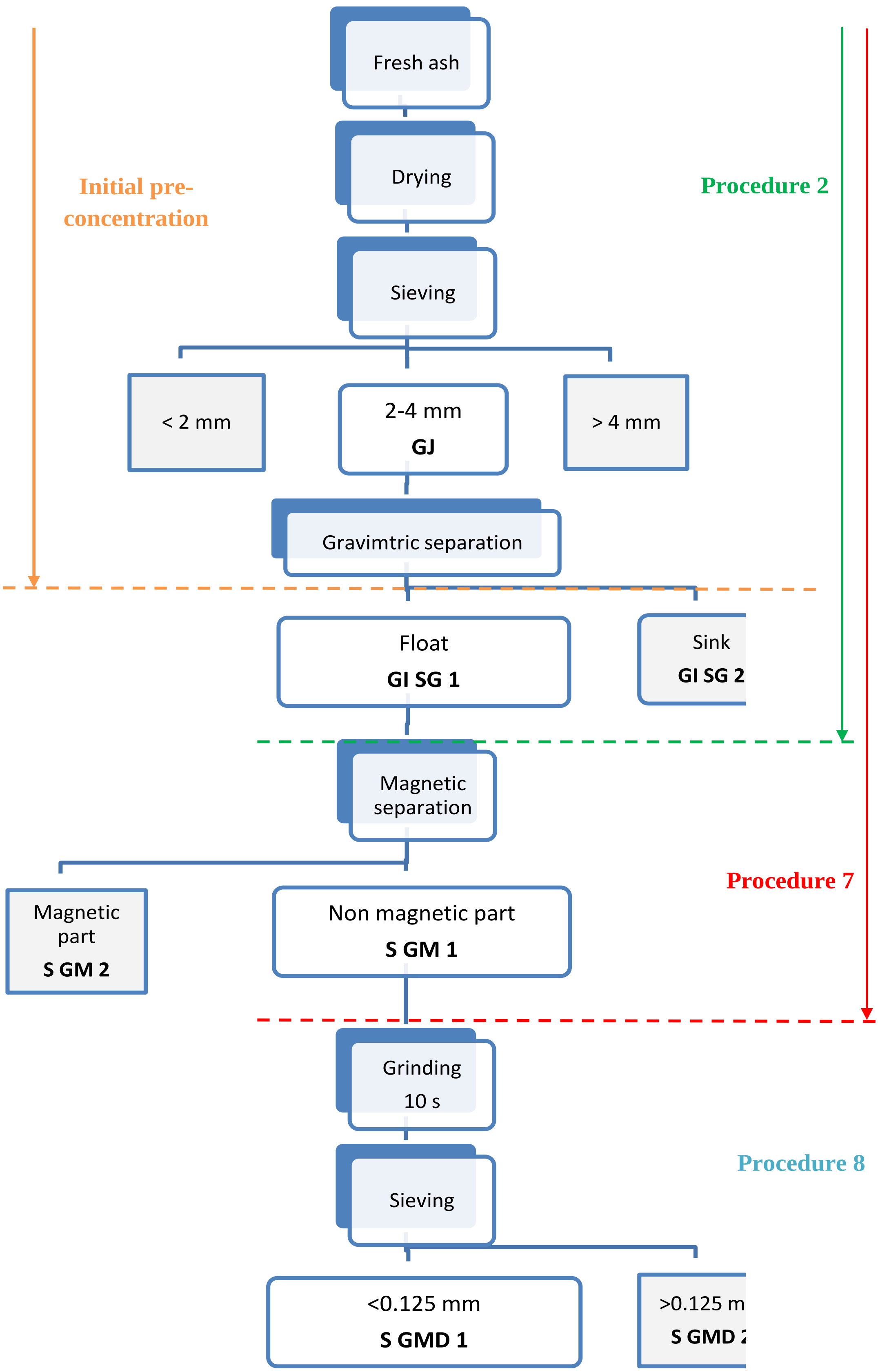
The procedures have at least two stages of char enrichment, the first stage being sieving and dimensional separation in all cases.

The procedures were divided into three categories:

- procedures derived from dimensional separation – see fig. 1
- procedures derived from gravimetric separation – see fig. 2
- procedures derived from magnetic separation – see fig. 3



Fig, 1. Scheme of pre-concentration procedures based on dimensional separation



Fig, 2. Scheme of pre-concentration procedures based on gravimetric separation

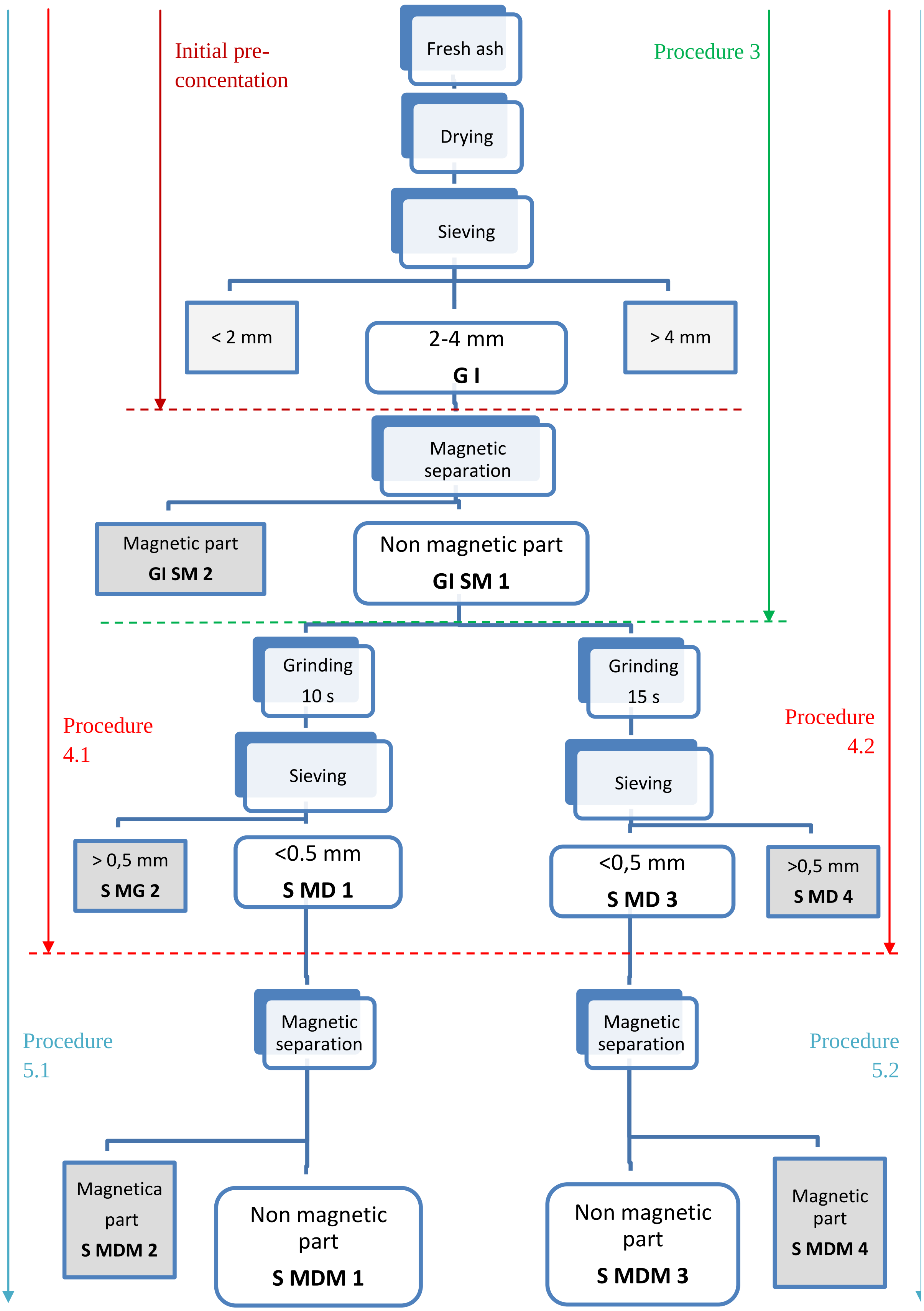


Fig. 3. Scheme of pre-concentration procedures based on magnetic separation

The twelve pre-concentration procedures have been tested and, to compare the results, four parameters have been defined:

- RMS - the mass separation rate as the ratio between the separate mass (M_sep) and the initial mass of the sample that is subject to the separation of a single separation procedure (M_i):

$$RMS = \frac{M_{sep}}{M_i}$$

- RGS - the overall separation efficiency as the product of the mass separation yields where the initial sample is successively subjected to several separation procedures. RGS is actually the ratio of the final mass (M_ (sep, n)) and the initial mass of the sample that is successively subjected to several separation procedures (M_i).

$$RGS = RMS_1 \cdot RMS_2 \cdot \ldots \cdot RMS_n = \frac{M_{sep,1}}{M_{ini}} \cdot \frac{M_{sep,2}}{M_{sep,1}} \cdot \ldots \cdot \frac{M_{sep,n}}{M_{sep,n-1}} = \frac{M_{sep,n}}{M_{ini}}$$

- GCC - rate of char concentration as the ratio between the fixed carbon content in the final sample and the initial sample:

$$GCC = \frac{CCF_{fin}}{CCF_{ini}}$$

- GRC - rate of char recovery as the ratio of the char mass in the final sample to the char mass in the initial sample. GRC is, in fact, the product of the mass yield of separation and the degree of concentration of char.

$$GRC = \frac{M_{char,fin}}{M_{char,ini}} = \frac{M_{sep,n} \cdot CCF_{fin}}{M_{ini} \cdot CCF_{ini}} = RGS \cdot GCC$$

3. CONCLUSION

We focused on the bottom ash provided by Govora CHPP and we developed twelve char enrichment procedure by repeatedly removing the inorganic matter through various processes such as sieving, flotation, magnetic separation.

In order to compare the results, four parameters have been defined:

The results and discussion are presented in the second part of the paper.

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